

Evaluation of Physical Development in Ukrainian City Pupils During 35 Year - Monitoring Period (1974 – 2009)

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ABSTRACT

The aim of the comparative analysis of physical development parameters in Ukrainian city pupils during 35 year monitoring period was the determination of level and harmony of physical development of modern pupils. A total of 2453 city children and teenagers at ages 6-17 (1224 boys and 1229 girls) were examined. The results were compared with those obtained in 1974. The analysis of physical development was carried out using standard tables containing regression scales of body length. The results showed that no more than 57-59% of pupils have average and harmonious physical development while every 6th boy and every 5th girl is overweight. A significant qualitative and quantitative deterioration in physical development and morphofunctional state was observed in children of both sexes during their school years, which is most expressed in boys. From the 1st up to the 4th grade pupils with disharmonious development become 2.5 times weightier (about 12%), and up to the 9th grade, 7 times weightier (about 20%).

Key words: anthropometry, physical development, pupils, Ukraine

Introduction

The research and analysis of physical development of school age children is a relevant problem in modern anthropology. It enables the characterization of children's health through social and medical monitoring, and the use of the received results in interfacing fields.

Whiteford¹ emphasizes the importance of multidisciplinary research in modern anthropology. The combination of anthropology and social marketing applied to health brings research to a qualitatively new level, and expands essentially the studied problems.

Apouey² emphasizes the importance of socioeconomic and social conditions for child physical development. The existence of a direct correlation of body weight and body weight index with the level of income has been confirmed. This association amplifies during adolescent period. Other studies indicate the interrelation between child physical development and the level children's morbidity³, as well as the need to consider the level of individual somatic health as a safe zone of intensive physical activity, which demands adequate pedagogical control⁴. The performed analyses showed that in 11-13 year old girls motor abili-

ties' training level was effective if it became a component of mastered motor skills. In such studies, the augmentation of body height parameters (12%), body weight (13%), vital capacity of lungs (12.8%), right wrist strength (15%), left wrist strength (13.8%) was observed⁴.

Many years of longitudinal research of a sufficiently large sample allow the determination of dependences of body height and maturing, and a differential approach to the development of different child somatotypes. Data of such studies give the opportunity to examine changes of a children's population and to develop regional standards of physical development. Besides, the obtained results allow the evaluation of both current and future generation, and the use of available information for both diagnostic and prognostic purposes.

The comparative analysis of child physical development carried out in Moscow and Kiev⁵ reported the lack of statistically significant differences in body length. The exceptions were data at ages 10-16 for boys and 12-17 for girls. Modern teenagers of both cities surpass their peers of the previous generation in body length. The chest circumference and body weight at all ages were higher in Moscow teenagers for both sexes, while a negative tendency of aug-

mentation was found for overweight children. In another study, authors investigated the influence of 3-week intensive interval training on parameters of body structure, and the maximum aerobic and anaerobic power among teenagers⁶. According to their results, the intensive interval training can be effective in rising teenagers' bioenergy indicators.

In modern conditions the society has to create a development strategy to ensure the maximum possible level of health and quality of life, which is impossible without the knowledge of tendencies throughout a rather long period. The condition of children's physical development is the generalizing health parameter. A large number of studies in this direction contributed to the availability of such data, objectivity of its evaluation, and insights into changes influenced by different factors.

Other authors⁷ conducted the comparative research of morphological features in children of Russian and Kalmyk nationalities based on body self-perception. The most important characteristics for girls and boys were body weight and body length respectively. Morphofunctional parameters which are rather widely used in evaluations of youth physical development^{8,9}, allow predicting success of young people in the chosen kind of activity.

Similar results were obtained by another study¹⁰ on gender differences in children's self-description of physical development. It was found that boys linked health with their own self-concept and physical qualities: physical coordination and flexibility. Girls linked health with physical activity and their own physical skills. Boys related physical coordination to strength skills, while girls related it only to their appearance. It was also revealed that boys linked directly their own self-concept with strength and physical activity. These parameters were not of great importance for girls. The value of youth self-concept was also confirmed in relation to physical exercise by a study which determined the self-concept of personality and temperament features of young people¹¹. The study of students' temperament structure showed low demand in mastering of objective world and strive for mental and physical labor.

The place of residence is one of the factors that can affect health level. The level of social conditions and improvement of standard, availability of sanitary conveniences, and development of information networks are among factors significantly influencing physical activity and physical development. Besides, global tendencies of urbanization affect features of child physical development as confirmed by the study of school age girls and students from Eastern Siberia (Russia)¹². This region is characterized by adverse ecological and climatogeographical characteristics. The authors discovered three main periods of changes in the dynamics of female physical development. The highest results of physical development parameters were recorded at preschool age. The ages 7-8 were critical (transition from the 1st to the 2nd stage). The smallest values of these characteristics were found for senior students (after ages 17-18) along with the relative stabilization of these parameters.

Thus, monitoring physical development of children allows evaluating health features and predicting changes in child population.

The purpose of the present research was the comparative analysis of physical development parameters in Ukrainian urban students throughout 35 years of monitoring, and the determination of the level and harmony of their physical development.

Materials and Methods

A total of 2453 city children (1224 boys and 1229 girls) and teenagers at ages 6-17 were examined within the study. Only children of Slavic nationality were analyzed (Russians, Belarussians, Ukrainians, and children from mixed marriages between these nationalities).

The methods included individualizing (longitudinal monitoring) and generalizing methods (transversal monitoring) for physical development evaluation. Anthropometric parameters were defined according to the demands of the unified technique with use of standard tools^{13,14}. The key somatometrical parameters evaluated were body length, body weight and chest circumference. The comparison with data from 1974 was made for the analysis of changes in physical development during the monitoring period¹⁵.

Official standard tables containing scales of body weight regression according to body length¹⁶ were used for the evaluation of physical development. The level of development was determined by body length interval. The harmony of development was evaluated using body weight and chest circumference. Development was considered as harmonious if the actual parameters were within the interval ($M \pm 1\sigma$).

The data collected included the duration of children's residence in the region, period spent in educational institutions, and existence of chronic somatic diseases. The statistical analysis of the results was carried out with the use of the licensed software Excel, and arithmetic means, standard deviations and moderate errors were determined. The statistical significance of differences within groups was evaluated by means of parametrical Student t-test considering sample size.

Results

The results of the comparative evaluation of anthropometric parameters of city children aged 7-17 years for the years 1974 and 2009 are presented in tables 1-3. The results of the dynamics of body length in the course of 35-year monitoring period are given in table 1. According to the results of 2009, body length augmentation in comparison with peers in 1974 was found to be significant ($p < 0.01$) and highly significant ($p < 0.001$) for both sexes at all ages (except for 8 year old children). After the age of 11, children in 2009 were significantly taller ($p < 0.001$) than their peers in 1974. Thus, body length of 11 year old boys

was 142.74 ± 0.51 cm in 1974 and 147.74 ± 0.54 cm in 2009, while girls' body length was 143.86 ± 0.50 cm and 146.35 ± 0.54 cm respectively. For boys aged 15, this parameter was 168.43 ± 0.68 cm in 1974 and 171.24 ± 0.53 cm in 2009; for girls aged 15 this parameter was 161.36 ± 0.46 cm and 163.38 ± 0.49 cm respectively. Thus, boys' body length in 30 years increased for 2.13 cm; 11-12 year old students became taller for 5 cm; 13-15 year old students became taller for 3 cm, and girls' body length increased for 2.05 cm.

The dynamics of students' body weight during the monitoring period is given in table 2. The proximity of parameters for 7 year old pupils was observed, though girls' body weight in 1974 was lower than boys' body weight in 2009. A decrease of body weight for 8 year old boys was observed in the course of the monitoring period. There were no significant differences in the group of 9 year old pupils. A decrease of body weight for 10 year old girls was found in 2009 year ($p < 0.01$). Girls were overweight in 1974 as compared to boys, while a considerable augmentation of this parameter was observed for 11 year old boys in 2009 as compared to their peers in 1974. Similar, but more expressed changes were confirmed for 12 year old pupils. Body weight augmentation was observed in girls of 1974 as compared to boys. Both sexes were found to be considerably overweight at age 12 in 2009. Also 13 year old students in 2009 were also significantly more »weighty« than their peers in 1974. No significant changes of this parameter were found for 14 year old pupils. Students aged 15 of both sexes were found to be overweight in 2009. 16 year old boys were lighter than their peers in 1974, while no significant differences for this parameter were found in girls. At the same time, sex dimorphism was found at ages 16-17 in 1974, when boys were »weightier« than girls, while in 2009 17 year old girls were significantly lighter than their equals in age in 1974.

In the studied age and gender groups the highest deficiency of body weight was determined in 8 and 16 year old boys, and in 8, 10 and 15–17 year old girls ($p < 0.001$).

The comparison of boys' body weight in different decades revealed that children at ages 11-13 today significantly exceed their equals in age living in 1970's. Similar differences were determined for 12-13 year old girls. For 11 year old boys body weight was (35.52 ± 0.48) kg in 1974 and (39.65 ± 0.53) kg in 2009; body weight of girls at age 12 was (41.60 ± 0.73) kg and (44.09 ± 0.64) kg respectively. For 13 year old boys body weight was (44.76 ± 0.82) kg in 1974 and (47.77 ± 0.58) kg in 2009, while body weight of girls was (46.60 ± 0.93) kg and (48.79 ± 0.59) kg respectively.

The results of changes in chest circumference during 1974-2009 periods are given in table 3.

According to the results, primary school pupils were characterized by proximity of monitored parameters. At ages 7-9 girls in 1974 had lower chest circumference than boys of the same age in 2009. A significant reduction of this parameter was found in 8 year old pupils throughout monitoring. There were no significant differences in 10 year old pupils.

A significant ($p < 0.01$) and a highly significant ($p < 0.001$) increase in chest circumference was found in 12-14 year old girls and also in 11-12 and 15-17-year old boys as compared to their peers in 1974. Thus, in 11 year old boys chest circumference was (67.93 ± 0.38) cm in 1974 and (70.73 ± 0.40) cm in 2009; in 12 year old girls, chest circumference was (71.52 ± 0.55) cm in 1974 and (73.14 ± 0.47) cm in 2009 respectively. A significant excess of values of this parameter was observed for pupils of the 70's of the last century at all other ages and both sexes.

The results of the evaluation of physical development of modern city pupils at ages 6-17 are given in tables 4-5 according to the official standards. Average development was determined in 69% up to 71% of children. 11% – 13% of children belong to the group with the level above the average. The development of about 13% of the examined pupils is below the average. No significant differences were found by sex in the level of physical development.

The distribution of urban children according to the harmony of development is presented in table 5. Morphofunctional state was defined as harmonious, disharmonious and critically disharmonious. The analysis of distribution of city pupils according to the harmony of their morphofunctional state showed a statistically significant prevalence of girls with critically disharmonious development. It is caused by a critical deficiency of body weight and chest circumference as compared to boys $[(5.05 \pm 0.63)\%$ and $(2.45 \pm 0.44)\%$ respectively, ($p \leq 0.001$).

The most of city children $(4.97 \pm 0.62)\%$ with critically disharmonious development during the monitoring period reached the average level of physical development. There was significantly lower number $(1.96 \pm 0.39)\%$ of boys among this children. The critical disharmony of development was caused by excess of body weight and deficiency of chest circumference.

It is known that the fundamental laws of nature cause normal distribution. It is possible to suppose that in a socially safe population the quantity of children and teenagers with »average physical development and harmonious morphofunctional development« has to be about 68%¹⁷. However, such result was not obtained for the sample of the children studied. In general, $(59.48 \pm 1.40)\%$ of girls and $(57.17 \pm 1.41)\%$ of boys had average and harmonious physical development out of more than two thousand studied pupils.

About 16.7% city boys and 18% girls, i.e. every 6th boy and every 5th girl, was overweight and/or had deficiency of chest circumference. Among 6 year old children (pupils of the 1st grade), $(77.67 \pm 4.1)\%$ of girls and $(92.31 \pm 2.61)\%$ of boys had harmonious development ($p \leq 0.01$). Critically disharmonious development was found in $(11.65 \pm 3.16)\%$ girls and $(3.85 \pm 1.89)\%$ boys ($p \leq 0.05$).

It was found that by the end of the 4th school grade the number of boys with disharmonious development practically increases 2.5 times, from $[(3.85 \pm 1.89)\%$ up to $(11.76 \pm 3.57)\%$ ($p \leq 0.05$)). The observed increase of this parameter is 1.5 times in girls, from $(10.68 \pm 3.04)\%$ up to $(15.53 \pm 3.57)\%$. In this case there is a weak correlation. A sig-

nificant prevalence of children with disharmonious development (15.84 ± 3.63 %), ($p \leq 0.01$) was found in males at the age of 13, at the beginning of puberty and »growth spurt« It is three times higher than in girls of the same age (4.85 ± 2.12 %).

In the 9th grade every 5th boy (19.61 ± 3.93 %) has disharmonious development, which is 7 times more than in the 1st grade pupils of the same sex ($p \leq 0.001$). Similar negative and statistically significant changes were not detected for 9th grade girls. The number of children with disharmonious development increased 1.6 times from the 1st up to the 9th grade. Their specific weight was (16.00 ± 3.67 %).

Discussion

Longitudinal population studies of children's and teenagers' physical development allow evaluating its changes in time as well as the determination of health changes and main risk factors. The augmentation of body length and body weight during the monitoring period was previously indicated by research on body height and level of nutrition in school children¹⁸. One of the main features of physical development is the increase of specific weight of adipose tissue. It is linked to hypokinesia and improper feeding. Other research¹⁹ showed the correlation of factorial loads of the most significant parameters characterizing the coordination of motor structure in different age groups of school children, and a significant influence of changes in body proportions on the formation of compensatory mechanisms in the course of body maintenance in vertical position. Works of other authors²⁰ confirmed the connection between morphological features and kinematic parameters, which changes with age. The main factor in the determination of jump length in children is length of extremities, while in adults it is the body weight and percentage of lipid deposits. A study on the dynamics of anthropometric parameters performed in Lithuanian pupils during 2000-2015 period, showed that in 16-19 year old Lithuanian girls during the monitoring period the body weight index considerably increased, from 20.09 up to 21.32 kg/m², ($p < 0.001$)²¹.

The established augmentation of children's body length has to be evaluated as an intensification of processes of growth and development, as indicated also by other studies²². The comparative analysis of anthropometric parameters of school children from Novi Sad (Serbia) showed that average values of boys' body length were from 125.39 cm (6 year old) up to 175.09 cm (15 year old). Average values of girls' body length were from 124.07 cm (6 year old) up to 165.77 cm (15 year old). Our results presented in Table 1 are quite similar to these data.

The comparative statistical analysis of physical development parameters in children from Central and Northern Kazakhstan revealed significant regional differences in some anthropometric parameters²³. In this sample, body length of 12 year old girls' was significantly higher than in boys of the same age irrespective of nationality or

residence. From age 14, body length of boys was significantly higher than in girls of the same age²³. Our data confirm a similar tendency of the augmentation of boys' body length in comparison to girls at that age.

The analysis of body weight is rather important as this parameter characterizes health level. Some authors²⁴ maintain that body weight is the main factor affecting physical development. A direct connection between body weight and strength of wrist muscles and physical coordination was already determined²⁴. The high informational content of body weight is confirmed by its use in different studies. One study²⁵ analyzed features of feeding behavior of Ukrainian pupils, indicating that body weight was one of the main parameters characterizing the nutritional condition. The dynamics of body weight allows predicting health changes connected with nutrition. Another study²⁶ confirmed the existence of correlations between anthropometric parameters and level of arterial blood pressure. The main correlation was observed between body weight and systolic arterial blood pressure.

The analysis of body weight of children in the 1970's and their current peers allows drawing the conclusion that nowadays there are different tendencies in the dynamics of body weight. It demands, however, additional research devoted to the study of interrelations of body weight with other anthropometric measures. Perhaps, changes of body weight reflect adverse social and economic changes in modern society.

The analysis of body weight carried out within a study of Serbian children showed that average values of boys' body weight varied from 25.58 kg (6 year old) up to 61.38 kg (15 year old)²². Average values of girls' body weight varied from 23.94 kg (at primary school age) up to 54.46 kg (15 year old). The beginning of the accelerated development in boys was at ages 11-13 and in girls at ages 9-12.

The results presented in Table 2 demonstrate the existence of similar tendencies of physical development in Ukrainian pupils. For the first time body weight of 11 year old boys exceeds that of girls. Then follows a significant excess connected with puberty since age 14. The chest circumference of Kiev pupils in 2009 was generally lower than in the 1970's, attesting to »gracilization« of body build. It has to be interpreted as a confirmation of the deterioration in the development of muscular system in modern pupils and an adverse sign in terms of the forecast of their physical health.

The evaluation of physical development allows the analysis of the structure of physical health in children, drawing conclusions about health changes, and predicting child physical fitness.

Inanç²⁷ points out that evaluation of children's physical development is an important tool of child anthropometry. The determination of children with the highest average values allows controlling their health. The time scale of monitoring period in our study enabled the determination of a vector of changes of somatic development of children's population. The parameters of negative changes in physical development of school city children of both sexes in-

clude disharmony in body weight with prevalence of its deficiency, and body build »gracilization« effects during puberty.

Similar studies carried out among school children showed average physical level in 60.38% of cases, below the average level in 16.98%, low level in 8.49%, above the average level in 10.38% and 3.77% cases²⁸. Specific weight of average physical development in high school students was 13.27%. Among children of the advanced school age the average level of development was found in 22.32% cases, below the average level in 25.89%, low level in 11.61%; above the average level in 31.25% and 8.93% cases. Under normal conditions the acceleration of growth in boys happens 2 years later than in girls (at ages 12-13 for boys and 11 for girls). But in children living in high mountains this phenomenon was observed in 15 year old boys and 14-15 year old girls. The dynamic increase of body length and body weight is late and slow, and leads to violation of individual progress. The mutual disharmony growing with age of anthropometrical parameters was diagnosed in 40.51% of children, while it was particularly high among boys. Thus, it seems that the long and stable stunted growth and body weight before and during puberty could be related to chronic stress in the organism.

The analysis of harmony level of physical development gives the opportunity to determine unsuccessful children in terms of physical development as one of health criteria. This confirms the adequacy of use of anthropometrical parameters as instruments of health monitoring.

Other authors²⁹ connect changes in physical development in children from Belarus with ecological conditions due to the consequences of Chernobyl disaster. It is specified that age 13 is critical for growth and development. The

boys' acceleration only begins at this age, when girls' acceleration finishes. The authors reported a significant increase of specific weight in children with obesity in comparison with children in the 1990's, due to insufficient physical activity and complex adverse ecological factors²⁹.

In our opinion, the critical disbalance of harmony parameters has to be evaluated as a risk factor of pre-nosological health conditions, as part of a complex of preventive and improving actions.

Conclusion

The presented research determined the following consistent patterns and features of physical development of Ukrainian city pupils during the 1974–2009 period:

- Modern city children at ages 7-17 of both sexes are significantly »taller« and »weightier« than their equals in age during the 1970's, and according to the chest circumference results such tendency appears from the middle school age;
- No more than 57-59% of pupils have average and harmonious physical development;
- Every 6th boy and every 5th girl are overweight and they have deficiency of chest circumference;
- A significant qualitative and quantitative deterioration in physical development and morphofunctional state was observed in children of both sexes during their school ages, which is more pronounced in boys. From their 1st up to the 4th grade children with disharmonious development become 2.5 times weightier (about 12%), and up to the 9th grade – 7 times weightier (about 20% respectively).

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PROCJENA FIZIČKOG RAZVOJA UKRAJINSKIH GRADSKIH UČENIKA OD 1974. DO 2009. GODINE

SAŽETAK

Provedena je komparativna analiza parametara fizičkog razvoja ukrajinskih gradskih učenika u razdoblju od 35 godina s ciljem određivanja razine i harmoničnosti tjelesnog razvoja suvremenih učenika. Ispitano je ukupno 2453 djece i tinejdžera u dobi od 6-17 godina (1224 dječaka i 1229 djevojčica). Dobiveni rezultati uspoređeni su s podacima iz 1974. godine. Analiza fizičkog razvoja provedena je prema standardnim tablicama koje sadrže regresijske skale duljine tijela. Rezultati istraživanja su pokazali da samo 57-59% učenika ima prosječan i skladan fizički razvoj, a svaki 6. dječak i svaka 5. djevojčica imaju prekomjernu težinu. Opaženo je značajno kvalitativno i kvantitativno pogoršanje fizičkog razvoja i morfofunkcionalnog stanja kod djece oba spola tijekom razdoblja školovanja, koje je najizraženije kod dječaka. Od prvog do četvrtog razred učenici s neharmoničnim razvojem postaju 2,5 puta teži (oko 12%) a do 9. razreda, sedam puta teži (oko 20%).